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Chapter 12

Domestic Cats as Laboratory Animals

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I. INTRODUCTION

A. Unique Contributions of Cats to Biomedical Research

Of the 1,267,828 nonrodent animals used in research in the United States in 1997, only 26,091, or 2%, of these were cats. Furthermore, use of cats in research in this country has declined dramatically during the past two decades from a high of 74,000 in 1974, amounting to a 65% reduction (Animal Care division of APHIS, USDA). If the importance of cats as a research species was judged entirely on these numbers, one might conclude incorrectly that cats do not contribute significantly to biomedical research. In fact, cats contribute uniquely to science, and their special biological characteristics and diseases rank them as the favored species for several disciplines, including experimental neurology, some aspects of ophthalmology, retrovirus research, inherited diseases, and immunodeficiency diseases.

B. Feline Genomics and Inherited Feline Diseases as Models of Human Diseases

The domestic cat (*Felis cattus*) is one of only a few mammals other than humans and mice for which extensive information has been generated on its genome. This unusual emphasis on feline genomics is driven partially by the substantial number of naturally occurring inherited diseases that are useful as models of their human counterpart and partially by the interest of the National Cancer Institute's Laboratory of Genomic Diversity in host factors that determine susceptibility to feline leukemia virus and feline immunodeficiency virus. Scientists of this laboratory have made major contributions to characterization of the feline genome. At their website, <http://rex.nci.nih.gov/research/basic/lgd/front_page.htm>, they provide primer sequence and other information on 711 loci in the cat genome, many of which are homologous to human anchor loci or coding gene sequences. They also provide a genetic map for the cat with comparisons with syntenic chromosomal locations in humans, which shows an extraordinarily homology between gene locations of these diverse species. For example, of the 9 loci that map to autosome D1 of the cat, all are located on human chromosome 11p.

With the development of powerful tools of molecular biology that permit careful dissection of genomes, there has been a explosive interest in human inherited diseases and their animal counterparts. There was an unrealistic expectation that knockout transgenic mice would provide all models needed to study specific gene mutations. The reality is that mice with induced malfunction of many genes have no apparent disease, have lethal disease, or have clinical diseases that do not mimic the corresponding human disease. This is in sharp contrast to many inherited diseases of cats, which are virtually identical to the analogous human disease with respect to clinical presentation, patterns of inheritance, histopathology, and biochemistry (see Table I). These models continue to be exceedingly important in research on pathogenic mechanisms and potential therapeutic modalities.

C. Infectious Disease Models

Several naturally occurring infections of cats have been used experimentally for research on analogous human diseases. The three that are highlighted here were selected because of recent discoveries that have led to development of these models and because of the importance of the human disease for which these unique cat diseases provide excellent experimental models.

1. Feline Leukemia Virus Disease as a Model of Viral Oncogenesis

Domestic cats have the highest incidence of naturally occurring lymphoid malignancies of any nonrodent mammal. Feline leukemia virus (FeLV) is an oncornavirus that causes lymphosarcoma, leukemia, and aplastic anemia in cats and is similar to leukemia viruses of mice (murine leukemia virus) and chickens (avian leukemia virus). The feline disease is considered to be an important model for several characteristics of retrovirally induced disease, particularly hematopoietic tumors such as acute lymphoblastic leukemia and lymphoma. Paradoxically, the virus also causes immunodeficiency and myelosuppression. After infection, cats are persistently viremic and virus is excreted, particularly through saliva and nasal secretions. A regressive, nonviremic form is also recognized. Serological tests are based on detection of the major viral core protein of FeLV (p27 gag) in serum or plasma by enzyme-linked immunosorbent assay (ELISA). Strengths of this model include substantial information on FeLV, pathogenesis of the disease, responses of the immune system, availability of FeLV strains of known virulence, and the ease of inducing infection and disease in cats (Hoover and Mullins, 1991).

2. Feline Immunodeficiency Virus Disease as a Model of Human AIDS

Valid animal models of human acquired immunodeficiency syndrome (AIDS) are essential for research on pathogenesis, therapy, and vaccine development. Immunodeficiency disease of cats caused by the lentivirus feline immunodeficiency virus (FIV) is considered by many to be one of the most relevant naturally occurring models of AIDS (Gardner, 1989). The advantages of the feline disease model include the similarities with HIV (the human lentivirus), similarities in pathogenesis and clinical signs, ease of experimental infection, and predictable disease progression. The weakness of the model relates to the

Table I

Feline Inherited Diseases[a]

Disease[b]	Protein affected	Gene affected	Mutation	Reference(s)
Amyloidosis	AA amyloid	Nk	Nk	Gruys *et al.* (1998), Boyce (1984)
Chediak–Higashi syndrome	Nidogen?	Nk	Nk	Kramer *et al.* (1977)
Chylomicronemia	Lipoprotein lipase	*LPL*	A412G exon 8	Jones *et al.* (1998)
Ehlers–Danlos syndrome, type II	Procollagen peptidase	*PLOD*	Nk	Patterson and Minor (1977)
Endocardial fibroelastosis Barth's syndrome	Nk	Nk	Nk	Paasch and Zook (1980)
Feline spongiform encephalopathy	Prion protein	*Prn*	Nk	Prusiner (1995)
Globoid cell leukodystrophy, or Krabbe's disease	Galactocerebroside β-galactosidase	Nk	Nk	Johnson (1970)
Glycogenosis II	α-1,4-Glucosidase	*GAA*	Nk	Sandstrom *et al.* (1969)
Glycogenosis IV	Glycogen branching enzyme	*GBE*	172-bp deletion	Fyfe and Kurzhals (1998)
GM_1 gangliosidosis	β-Galactosidase	*GLB1*	1-base sub CGTΔCCT, 1486	Baker *et al.* (1971), Baker *et al.* (1998)
GM_2 gangliosidosis	Hexosaminidase B	*HEXB*	fHEXKorat, 1-bp del fHEXBaker, 25-bp inversion	Muldoon *et al.* (1994), Martin *et al.* (1999)
Gyrate atrophy of choroid and retina	Ornithine δ-aminotransferase	*OAT*	Nk	Valle *et al.* (1981)
Hageman trait bleeding disorder	Factor XII	Nk	Nk	Kier *et al.* (1980)
Hemophilia A	Factor VIII	Nk	Nk	Cotter *et al.* (1978)
Hemophilia B	Factor IX	Nk	Nk	Maggo-Price and Dodds (1993)
Hurler syndrome, or MPS I	α-L-Iduronidase	*IDUA*	Nk	Haskins *et al.* (1979)
Hypertrophic cardiomyopathy	Nk	Nk	Nk	Kittleson *et al.* (1998)
Klinefelter's syndrome	X chromosome chimerism	Nk	Nk	Jones (1969)
α-Mannosidosis	α-Mannosidase	*MANB*	1748 del 4	Berg *et al.* (1997)
Maroteaux–Lamy syndrome, or MPS VI	*N*-Acetylgalactosamine-4-sulfatase, or arylsulfatase B	Nk	L476P D520N	Jezyk *et al.* (1977), Hopwood *et al.* (1998), DiNatale *et al.* (1992)
Methemoglobinemia	NADH-methemoglobin reductase	Nk	Nk	Giger *et al.* (1998)
MPS II, or I-cell disease	Phosphotransferase	Nk	Nk	Haskins *et al.* (1998)
Muscular dystrophy	Dystrophin	*DMD*	Nk	Gaschen *et al.* (1998)
Neuroaxonal dystrophy	Nk	Nk	Nk	Woodard *et al.* (1974)
Neuronal ceriod lipofuscinosis	Nk	*CLN-1*	Nk	Green and Little (1974)
Sphingomyelin lipidosis, or Niemann–Pick disease, type C	Sphingomyelinase	*NP-C*	Nk	Baker *et al.* (1987), Lowenthal *et al.* (1990)
Pyruvate kinase deficiency	Erythrocytic R-type pyruvate kinase	*R-PK*	13 del exon 6	Giger *et al.* (1998)
Polycystic kidney disease	Nk	*PKD1*	FCA476 linkage	DiBartola *et al.* (1998)
Porphyria	Porphyrin	Nk	Nk	Glenn *et al.* (1968)
Progressive retinal atrophy	Nk	Nk	Nk	Narfstrom *et al.* (1998)
Retinal degeneration	Nk	Nk	Nk	Bellhorn (1973)
Waardenburg's syndrome	Homeobox?	*PAX3*?	Nk	Bergsma and Brown (1971)

[a]For a current summary description of the relevant human diseases, see Scriver *et al.* (1995).
[b]MPS, mucopolysaccharidosis; Nk, not known.

limited variety of reagents available for identifying cells of the cat immune system. FIV has been molecularly cloned and resembles HIV in tissue and cell tropism but is antigenically distinct. Experimental transmission is achieved readily with infected blood or cultured cells. Cell-associated viremia occurs within 1–2 weeks and remains persistent, even after development of antibodies. Characteristic changes in the immune system include lymphadenopathy, neutropenia, decreased lymphocyte proliferative response, and increased susceptibility to opportunistic infections. B-cell lymphomas and myeloproliferative disease are seen in some infected cats.

3. *Helicobacter felis* Infection as a Model of Human *Helicobacter* Diseases

Helicobacter pylori is the etiologic agent responsible for a sequence of degenerative changes in the human gastric mucosa, starting with gastritis, progressing to peptic ulcers, and ending

in gastric carcinoma. Animal models are critically important for research on this prevalent and important human disease. Of several *Helicobacter* species infecting animals, *H. felis* is one of the most interesting and useful because of its wide host range, its ability to induce many, if not all, of the lesions found in human *Helicobacter* disease, and its adaptability to experimental induction in mice and cats. *Helicobacter felis* is a naturally occurring pathogen in cats that appears to be prevalent in some colonies, but its prevalence or significance as an agent of clinical diseases in the general cat population is not clear (Lee *et al.,* 1988; Perkins *et al.,* 1996). Fox *et al.* (1993) have studied this organism and the disease that it induces in mice and cats. It is clear from their work that *H. felis* contributes importantly to *Helicobacter* research as experimental infections of both mice and cats. In fact, these investigators have demonstrated that *H. felis* infection can faithfully reproduce all of the lesions found in the human disease (except ulcers), particularly those associated with the chronic infection (Enno *et al.,* 1995; Wang *et al.*, 2000). In addition to *H. felis* infection, cats appear also to be naturally infected with *H. pylori,* raising the possibility that domestic cats could serve as a reservoir for this human pathogen (Perkins *et al.*, 1996).

II. SOURCES OF CATS

A. Directories of Sources

Directories of sources for purchase of cats for use in biomedical research are available from the following organizations: (1) The Institute for Laboratory Animal Research is a unit of the National Research Council of the National Academy of Sciences and an excellent source of information about laboratory animal species. Its website <http://www4.nationalacademies.org/cls/ilarhome.nsf> provides an International Index of Laboratory Animals, which gives the location and status of 21 sources of laboratory cats worldwide. (2) The American Association for Laboratory Animal Science also maintains a website <http://www.aalas.org/> with a Reference Directory that provides details about commercial vendors of cats and an online search for papers published in *Laboratory Animal Science* that may pertain to use of cats in research. (3) Animal Care, the U.S. Department of Agriculture division that administers the Animal Welfare Act (AWA), maintains a website <http://www.aphis.usda.gov/ac/> that provides access to a variety of documents relating to the AWA, including a listing of licensed animal dealers.

B. Random Sources

Random-source cats derived from animal control agencies and dealers usually are not satisfactory research subjects because they frequently incubate or are actively infected with a variety of pathogens that are lethal or cause extended morbidity and that may be zoonotic. Intensive quarantine and conditioning procedures may or may not minimize these problems or be economical. Addition of cats of this type into facilities with stable colonies of cats introduces an unacceptable risk because, even after long periods of quarantine, inapparent or latent diseases such as feline leukemia, feline immunodeficiency disease, and feline infectious peritonitis may be transmitted to healthy cats. When the risks of morbidity and mortality from infectious diseases (including zoonoses), unknown reproductive status, and variable tractability of random-source cats are compared with those of cats derived from breeding colonies, use of purpose-bred cats clearly becomes a wise investment. An additional important consideration is public objection to use of cats in research after being surrendered to shelters. The sum of these important issues argues strongly against the use of random-source cats. One exception is the discovery of an interesting inherited disease or other diseases in cats that come from less than optimal environments and must be maintained in the laboratory but that may present some risks due to unknown or poor health history. In such cases it is important to impose a prolonged (8 to 12 week) isolation and observation period and to adopt intensive procedures to identify diseases, eliminate parasites, and vaccinate in order to prevent pathogen transmission (see Table II).

C. Commercial Purpose-Bred Colonies

Several commercial sources provide minimal-disease purpose-bred cats. Some of these colonies originated from cesarean-derived stock and have been maintained using strict barrier procedures to exclude pathogens (Festing and Bleby, 1970). In addition to assurance of good health and immunizations, vendor selection should be based on cats that are well socialized. Referrals from previous customers of these vendors will provide an indication of the health and behavioral characteristics of cats from a particular source. Vendors should be able to provide reports of health examinations and vaccine protocols. Serological test results are helpful to indicate exclusion of some pathogens, but these results may not be entirely reliable. Except for the higher cost involved, purpose-bred cats are preferred over cats from random sources.

D. Institutional Breeding Colonies

Projects that require a regular source of substantial numbers of normal cats or that depend on special characteristics such as perpetuation of an inherited trait can be satisfied best by establishment of an institutional breeding colony. Although this should not be undertaken lightly, it is within the capability of most organizations, as long as prescribed procedures are fol-

Table II

Basic Principles of Feline Infectious Disease Control

1. Establish the colony with disease-free stock and close the colony to any additions that do not meet or exceed the health status of the original stock
2. Regardless of the presumed health status of new additions, they should be subjected to the following before entering a closed colony:
   a. Isolation for at least 4 weeks, and longer if disease problems are suspected
   b. Thorough physical examination, including laboratory testing for FeLV, FIV, endoparasites, and ectoparasites. Other health screening such as hematology and clinical chemistry tests can be informative. Serologies should be repeated before termination of the quarantine
   c. Continued surveillance for clinical signs of infectious diseases that may be incubating at time of arrival
   d. Administration of vaccines, vermifuges, and ectoparasiticides as indicated. Repeat parasite control measures as recommended by the manufacturer
3. Vaccinate kittens at 8, 12, and 15 weeks of age against feline viral rhinotracheitis, calicivirus, and panleukopenia (FVRCP). Perform physical examinations of kittens at this time. Perform annual formal physical examinations, and administer FVRCP booster vaccines to adults once every three years. Breeding queens should be immunized after delivering kittens or before rebreeding to avoid infection of kittens *in utero* with modified live virus vaccines. Only killed panleukopenia vaccines should be used, because they confer highly protective immunization and live products may result in cerebellar hypoplasia if inadvertently given to pregnant queens
4. Conduct annual hematology, biochemical profile, and urinalysis on cats over 5 years of age. Kidney function is of particular concern, especially for breeding males
5. Repeat random serological screening for FeLV and FIV of at least 10% of the population annually
6. Instruct personnel to perform and report daily observation of all cats for changes in appetite, behavior, activity, or body condition. Changes require professional examinations
7. Immediately isolate any suspected sick cat, and conduct intensive diagnostic procedures, including necropsy examination if indicated

lowed. Careful analysis of cost and complexity should be undertaken to determine if this approach is justified. Thoughtful planning of facilities, operational procedures, and personnel assignments is essential for success. In this chapter we provide details on housing and reproduction that constitute basic information useful for establishing an institutional breeding program. When possible, breeders should be derived from minimal-disease stock, and a rigorous program of vaccination and health testing must be followed to assure continued good health. A knowledgeable and experienced professional should oversee the breeding colony operation and be responsible for training personnel. Animal care personnel must be given adequate time to interact with these cats, particularly young kittens, to assure proper socialization, which will lead to tractable cats that will be suitable for routine handling and experimental manipulations. Periodic assessment of reproductive success, ability to meet the needs of research projects, and colony health status is useful in making corrective adjustments and assuring that the breeding colony effort is economical and serves its intended purpose.

III. HOUSING

A. Caging Design and Operating Procedures

Success or failure of virtually every facet of laboratory cat management depends on housing design and operation. Although a significant advantage of using cats is their adaptability to high-density housing, such housing conditions can introduce potentially serious problems, including abnormal behavior, infectious disease transmission, and reproductive failure. Careful planning of facility design, adoption of strict management protocols, thorough training and supervision of personnel, and oversight by a knowledgeable professional are essential for success.

Cats are housed commonly in three basic arrangements: single cages, multiple runs within a room, and free ranging in a room. Space recommendations for each of these arrangements are suggested in the "Guide for the Care and Use of Laboratory Animals," but these should be regarded only as guidelines, because the specific needs of an experiment or a breeding colony may vary from these recommendations (Institute for Laboratory Animal Research, 1996). Substantial variance from these guidelines should be approved by the institutional animal care and use committee. Requirements of the Animal Welfare Act for space and density restrictions also should be consulted, because housing must comply with these regulations or exceptions sought for good cause (U.S. Department of Agriculture, 1995). Domestic cats develop highly structured interactive social groups, and most cats do not thrive in isolation (Fig. 1). Therefore, individual housing should be avoided unless particular experimental objectives dictate the use of single-cage housing or if caging is needed for short periods to permit collection of specimens, to administer material individually, or to accomplish treatment and/or observation. If caged, cats should be allowed out of their cages daily to exercise. At a minimum, cats should be housed in compatible pairs (Fig. 2) or, preferably, in small groups of the same sex or, if breeding, a few females with a tom. It is advantageous to house compatible pregnant queens together before they deliver because they usually share nursing and neonatal care. After delivery, pairing becomes more problematic.

Installation of multiple runs within a room is the most economical use of floor space. Depending on the dimensions of the room, runs can be 3 to 4 feet wide and 4 to 6 feet long and 6 feet high (12–24 ft^2 of floor area). The smaller runs are

Fig. 1. Cats housed singly often display anxiety-related stereotypic behaviors, including pacing, circling, and pawing (Overall, 1997). The authors strongly recommend group housing of cats to ensure social companionship and well-being as well as reliable research data.

adequate for pregnant or lactating queens and their litters or 2–3 juveniles. The larger runs are best for breeding groups of toms and queens, postweaning family groups, and single-sex adult groups. The "Guide for the Care and Use of Laboratory Animals" recommends 3 ft^2 of floor area for each cat weighing less than 4 kg and 4 ft^2 for cats over 4 kg (Institute for Laboratory Animal Research, 1996). Galvanized wire panels with 1-inch mesh fence wire and a top panel are inexpensive, durable materials for run construction. As indicated in Section III,E, one or more high-density plastic resting boards should be installed approximately 2 ft above the floor. When a free-ranging room arrangement is used, a chain-link fence "foyer" is usually constructed at the door inside the room to allow personnel entry into the room without giving any opportunity for a cat to escape into the hallway. Freestanding vertically oriented shelf structures provide environmental enrichment and opportunities to escape from socially dominant members of the group (Fig. 3).

Fig. 2. If cats must be kept in cages, they should be housed in compatible pairs. Resting boards and hiding places should be provided and serve to reduce stress.

Regardless of the cage arrangement used, wall, floor, and ceiling surfaces must be easily sanitized to achieve the pathogen control measures described below. Litter pans and utensils for food and water may be durable plastic or stainless steel and should be able to withstand 180° F wash water. Litter can be any clean, dust-free, absorbent material, including extruded corncob pellets. A minimum of one box per two cats should be provided. Soiled litter must be removed and replaced daily to minimize personnel exposure to infective *Toxoplasma* oocysts, to minimize cat-to-cat transmission of enteric pathogens, and to control odors. Room illumination must be controlled to provide duration, intensity, and spectrum of light that is optimal for specific needs of an experiment. In general, daylight-spectrum fluorescent tubes and daylight–dark cycles of 12:12 or 14:10 hr are useful and are required for successful breeding. Nesting boxes can be made of cardboard boxes, which are discarded when soiled. Enclosed boxes 24 inches square with a doorway cut into one side are useful for pregnant and lactating queens and their litters. Open boxes of the same size with walls 12 inches high are preferred for juveniles and adults. Boxes also serve to enhance the comfort of housed cats by providing places to hide and substrates for scratching, behaviors that are both fundamental needs of cats.

B. Animal Care Staff

Animal care staff must enjoy working with cats and be willing to interact with them to assure socialization and tractability. The staff members become aware of the personalities of "their" cats, which is necessary for detection of estrous cycling, potential health problems, or incompatibility of runmates caused by social dominance. The staff must be instructed thoroughly and must adhere to the prescribed sanitation protocol. Freshly washed garments such as surgical scrub suits should be worn and changed between rooms. Dedicated shoes should be used for each room, or disposable shoe covers should be worn in housing rooms. Face masks may be indicated, especially to prevent allergy or irritation from inhaling cat hair and dander. Individuals with established cat-related allergy must use tight-fitting face masks if they are required to enter cat housing rooms, which typically have high concentrations of allergen. Disposable gloves should be worn when handling soiled litter.

C. Feline Social Behavior

As natural predators, cats possess keen senses and heightened fight-or-flight responses, making them particularly susceptible

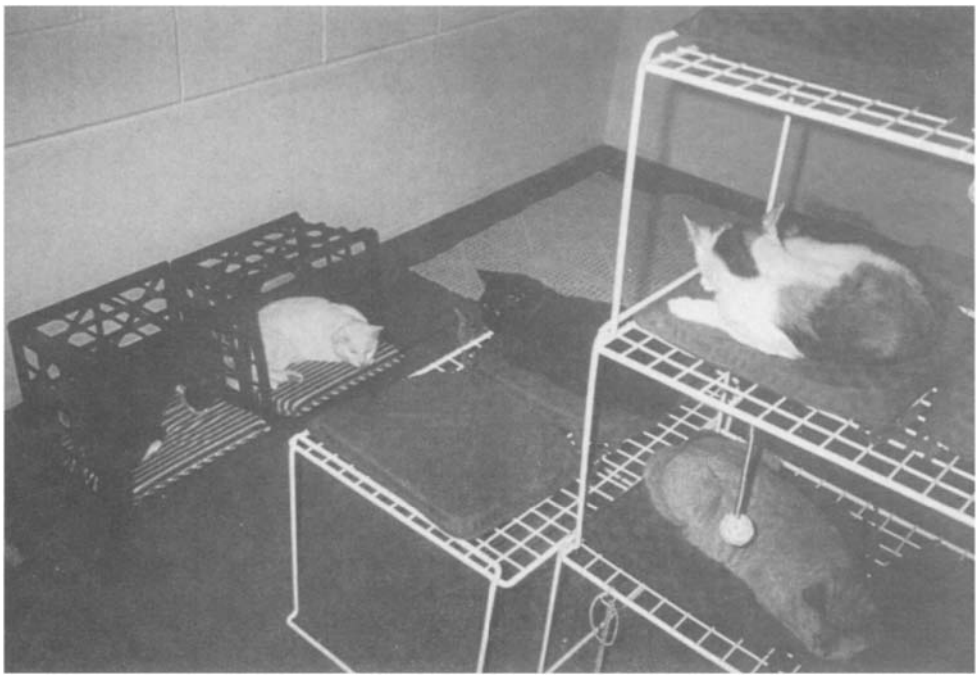


Fig. 3. Group housing of cats is preferred. Whereas single-housed cats tend to withdraw from handling, cats in a group environment tend to be more outgoing and interactive with human caretakers (Overall, 1997). Installation of shelving allows cats to utilize both vertical and horizontal space, functionally reducing overcrowding.

to environmental stress (Greco, 1991). In a laboratory setting, cats become readily entrained to daily activity patterns and respond strongly to their surroundings as well as to their human caretakers (Carlstead *et al.,* 1993). Unpredictable caretaking and handling are potent stressors in cats and may result in activity depression and withdrawal behavior. Overcrowding and insufficient resting and hiding places also increase stress (Carlstead *et al.,* 1993). In cats, the ability to control aversive stimuli through hiding profoundly decreases cortisol concentrations when measured over time or in response to adrenocorticotropic hormone (ACTH) (Carlstead *et al.,* 1993). As in many species, persistence of stress may compromise both immune and reproductive function (Griffin, 1989). In our experience, provision of proper social housing, exercise, environmental enrichment, and a predictable routine dramatically reduces the incidence of behavioral problems, including urine spraying, fighting, hiding, and silent heat.

With the exception of being solitary hunters, free-roaming cats are social creatures (Crowell-Davis *et al.,* 1997). The majority of their activities are performed within stable social groups in which cooperative defense, cooperative care of young, and a variety of affiliative behaviors are practiced. Affiliative behaviors are those that facilitate proximity or contact. Cats within groups commonly practice mutual grooming and allorubbing, in which cats rub their heads and faces against one another. This may serve as a greeting or as an exchange of odor for recognition, familiarization, marking, or development of a communal scent. Although both males and females exhibit affiliative behavior, these behaviors are more common in females. Play behavior and food sharing are common in kittens and adolescent cats.

Adult queens form social groups along with their kittens and juvenile offspring (Crowell-Davis *et al.,* 1997). Adult toms reside within one group or roam between a few established groups. The formation of social hierarchy occurs within groups of cats. Establishment of ranking order is a social adaptation that minimizes agonistic behavior between individuals within a group. Signals of dominance and submission may be subtle or obvious and include vocalization (growling, hissing), visual cues (facial expression, posturing of the body, ears, and tail), and scent marking (urine, feces, various glands of the skin). Maternal behavior is the primary social pattern of the female cat. Queens exhibit strong maternal instincts. They nest communally and care for each other's kittens. Cooperative nursing is common. Kittens raised in communal nests develop faster and leave the nest sooner than kittens raised by solitary mothers.

Although they are social animals also, tomcats commonly exhibit aggressive behavior toward one another during the establishment of dominance in relationships and during competition for territory, breeding, food, and other resources (Crowell-Davis *et al.,* 1997). Urine spraying and fighting are the most common undesirable male behaviors. In contrast to their interaction with other males, tomcats commonly display affiliative or "friendly" behavior with females regardless of their reproductive status. For these reasons, tomcats should be housed with spayed females when not breeding. If not used for breeding,

toms should be castrated. Neutering before puberty is the best for prevention of undesirable male behaviors such as urine spraying and fighting. If the sexually mature tomcat is neutered, these behaviors will usually subside within a few weeks, facilitating intersex group housing. Neutered males display more affiliative behavior toward both other males and females.

In the laboratory setting, once social order is established, particularly in a free-ranging room group, introduction or removal of individuals requires a period of adjustment that is usually stressful, induces fighting, and may disrupt breeding until a new social hierarchy and territorial limits are established (Hawthorne *et al.*, 1995; Overall, 1997; B. Griffin and H. J. Baker, unpublished observations, 1999). Even in multiple-run housing in a single room, rearrangement of run groups or even relocation of an intact group within the room may induce imbalance of the social order and anxiety. Therefore, every effort should be made to minimize reorganization of groups once they are established, and if restructuring is necessary, ample time should be allowed for restabilization of social order before experimental interventions are attempted.

D. Housing to Exclude Pathogens

As with other laboratory species, infectious disease control for cats should be based on exclusion. This requires that members of the colony are free from specific pathogens when the group is established, that vaccines are used where indicated to minimize susceptible populations, that rapid diagnosis and removal of ill cats be practiced rigorously, and, most of all, that the colony be closed to any new individuals that do not meet the rigorous health standards of the group. Disease transmission in breeding colonies is particularly problematic because there is usually a large proportion of juveniles in the group that are susceptible to infection between the lapse of maternal immunity and induction of protection by vaccines. Facility design that encourages a high level of sanitation and operational policies that assure cleanliness are essential to minimize infectious disease transmission. Daily operations should include vacuuming and mopping floors, disposal of soiled litter, replacing soiled cardboard nesting boxes, and washing utensils for water and food as needed. Weekly procedures should include washing litter boxes and food/water utensils in 180° F water, scrubbing soiled areas, and replacing nesting boxes. At least monthly, the room should be vacated, washed with hot water plus detergent, followed by disinfection with 10% hypochlorite. The premises should be dried thoroughly before cats are returned. Cats can be housed in airline-type carriers for the few hours required for this operation and become acclimated to the procedure. Individual cages should be accorded the same level of sanitation and processed through a mechanical cage washer weekly, because soiling in these closely confined cages is unavoidable, and daily hand washing is usually inadequate to maintain sanitation. Food and water should be separated from litter as much as possible.

E. Environmental Enrichment

Environmental enrichment is essential for behavioral health of closely confined cats. The most effective environmental enrichment is a staff that enjoys interacting with cats and is willing to spend adequate time to ensure their socialization. Rest boards are required for comfort and contentment of cats because cats instinctively feel more secure when they can perch at a high point. These also provide an opportunity for lactating females to have rest periods away from their young. Boards should be constructed of dense plastic and anchored in such a way that crevices that accumulate hair and debris are avoided. Metal is too cold for comfort, and wood cannot be sanitized adequately. Play items that stimulate activity such as plastic balls, rings, hanging ropes, and scratching boards are recommended as long as they are sanitizable or can be discarded if soiled.

IV. BREEDING COLONY MANAGEMENT

Because optimal conditions for exclusion of infectious diseases depend on use of purpose-bred cats, breeding colony management becomes exceedingly important for the use of cats in research. Fortunately, domestic cats are very prolific, and if reasonably uncomplicated guidelines are followed, as described here, high rates of production can be achieved in a laboratory environment with minimal complications. However, certain characteristics of feline reproduction are unique and must be recognized to achieve optimal breeding performance.

A. Estrous Cycle and Mating

On average, queens reach puberty or experience their first estrous cycle between 5 and 9 months of age, although the onset may range from 3.5 to 18 months of age. In addition to age, factors that affect the onset of puberty include breed, time of year or photoperiod, social environment, health, physical condition, and nutritional status. With proper health maintenance, nutrition, and control of light cycles, adolescent queens begin to cycle after attaining a body weight of 2 kg or more. Group housing, especially the introduction of a tomcat or estral queen, provides social stimuli that hasten the onset of estrus (Michel, 1993).

Free-roaming queens are seasonally polyestrous. In the Northern Hemisphere, the season begins in January or February after the winter solstice, as the days get longer, and lasts until fall. Anestrus persists from October through December until the next breeding season begins in January or February. Cats are extremely sensitive to photoperiod. In an environmentally controlled laboratory setting, 10 or more hours of light in a 24 hr period is required for reproductive cycling (Shille and Sojka,

1995). Maintaining a 14 hr light photoperiod and the use of natural daylight spectrum fluorescent bulbs assures the maximum fertility period and estrous cycling (H. J. Baker, unpublished observations, 1999). Estrous cycling typically occurs within 7–10 weeks of instituting such a light cycle (Dawson, 1941; Scott and Lloyd-Jacob, 1959); however, this period can be shortened if preceded by a nonstimulatory light cycle of 8 or fewer hours of light (Hurni, 1981), or if a tomcat or queen in estrus is introduced at the time of increasing the duration of light (Michel, 1993).

Peak sexual activity occurs between 1.5 and 7 years of age, with an average of 2–3 litters per year, with 3–4 kittens per litter (range 1–15 kittens per litter). Queens can bear 50–150 kittens in a breeding life of approximately 10 years if allowed to mate naturally. Like tomcats, queens are polygamous and rarely form long-term bonds with a mate, although they often display preferences for particular mates. If allowed, a female may accept a number of males, and therefore litters may have multiple sires. Adolescent queens (queens less than 1 year of age) and queens greater than 8 years of age tend to cycle irregularly and to have smaller litters, more abortions, more stillbirths, and more kittens with birth defects. Following a normal lactation and weaning, queens return to estrus in 2–8 weeks (average 4 weeks) (Feldman and Nelson, 1996). Many queens, however, return to fertile cycling while nursing their kittens (Löfstedt, 1982). If a queen aborts or if her litter is removed by 3 days postpartum, she will return to estrus in approximately 1 week. Queens may experience estrus during pregnancy. In fact, 10% of females experience estrus between the third and sixth weeks of pregnancy (Beaver, 1992). Fertile cycles are rare in the pregnant queen, but the development of different-age fetuses as a result of separate matings in different estrous cycles, known as superfetation, can occur. Although it is possible for a female to be continuously pregnant, nursing, or both, this high intensity of breeding is not recommended, because queens need a period of rest to regain body condition before the next period of pregnancy and lactation. Providing a period of short days (8 hr of light or less) for 4–6 weeks each year ensures anestrus, and reproductive rest and may ultimately enhance reproductive performance.

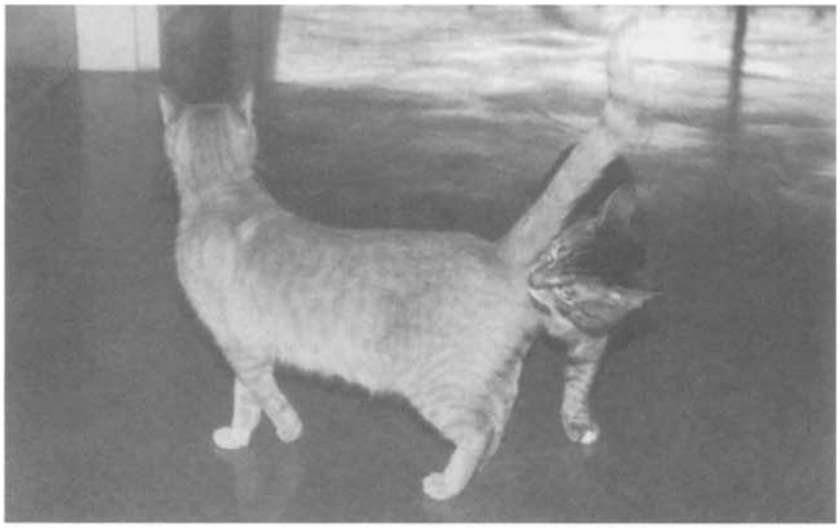
The estrous cycle of the queen consists of five phases: proestrus, estrus, interestrus, diestrus, and anestrus (Table III). Proestrus is the first phase of the feline estrous cycle and is defined as the time when queens attract toms but are not sexually receptive to them. Queens typically vocalize; rub their faces against objects, other cats, or human companions; and act "friendly." Rubbing usually progresses to rolling, and many queens will stretch and squirm in lateral recumbency, opening and closing their paws. Queens may assume a lordosis stance and tread with their hindlimbs, but upon introduction to a tom, they are not sexually receptive and may aggressively turn on the male, hissing and striking out with their claws. Proestrus lasts as little as 12 hours or up to 3 days. Signs may be overt or subtle. In fact, proestrus is not observed regularly in all queens. Many queens abruptly shift from anestrus behavior (no display of sexual behavior) to standing, receptive heat (estrus).

Estrus is the phase of sexual receptivity that lasts 4–7 days on average, with a range of 1–21 days. Coital contact does not shorten estrus. During this period, queens commonly vocalize and call to toms when approached. They crouch and posture in a lordosis stance, treading in place with their hindlimbs. In this position, the queen's ventral thorax and abdomen touch the floor, her perineum is elevated, and her tail is displaced laterally as she presents herself to her mate (Fig. 4). This stance can usually be induced by stroking the queen's back or dorsal rump. Occasionally, queens in estrus may exhibit urine spraying and marking. Behavioral estrus is more readily detectable in group-housed cats than in individually cage-housed cats. Silent heat may occur in "shy" or low-social-order queens. Behavioral signs of estrus are absent in these queens despite normal hormonal cyclicity. Decreasing housing density or housing groups of low-social-order queens separately from more dominant queens often results in normal displays of estrous behavior (B. Griffin and H. J. Baker, unpublished observations, 1999). There are various means of suppressing estrus in the queen, but ovariohysterectomy is the preferred method of contraception because it is safe,

Table III

Five Phases of the Feline Estrous Cycle

Phase	Duration	Signs	Hormone activity
Proestrus	½–3 days	Rubbing and rolling, "friendly," vocalization lordosis, treading, not receptive to tom	Ovarian follicular growth and estrogen synthesis
Estrus	4–7 days (range 1–21 days)	Sexually receptive, lordosis, treading, tail deflection, vocalization occasional urine spraying	Follicular phase, sharp rise in estradiol concentrations
Interestrus	1–3 weeks average (range 3 days–7 weeks)	None	Baseline estradiol concentrations
Diestrus	45–50 days average (range 30–100 days)	None	Formation of corpora lutea, progesterone-dominant phase
Anestrus	October–January (free-roaming)	None	Baseline estradiol and progesterone concentrations



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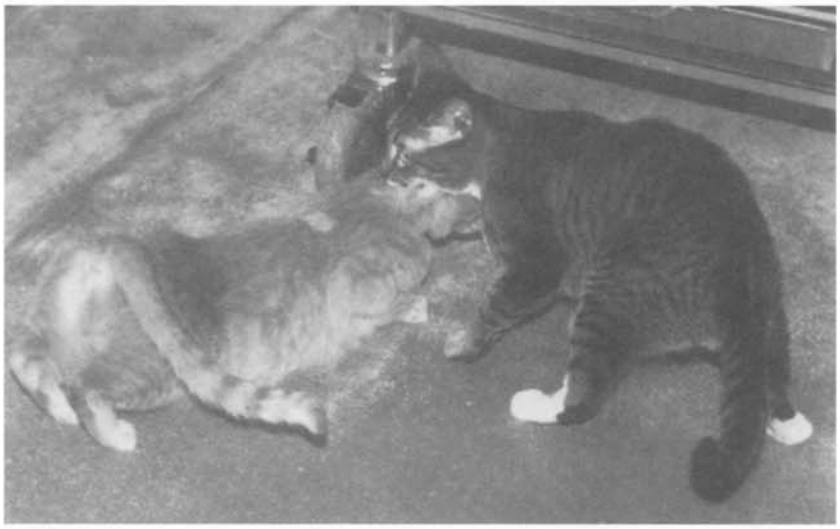


B

C

Fig. 4. Mating sequence of the domestic cat. (a) An interested male approaches a queen in estrus. (b) As the tom grasps her neck, the queen exhibits lordosis and tail deflection. (c) The tom mounts the queen. Intromission and ejaculation occur in 5–15 sec.

effective, and not associated with deleterious side effects. Progesterone compounds and androgenic compounds can suppress estrus but are not recommended, because of the wide range of severe side effects associated with their use.

Because cats are polyestrous and do not ovulate following every estrous period, an interestrous period or nonestrous interval commonly follows estrus. Interestrus is the interval of sexual inactivity between waves of follicular function in cycling queens. During this period, all breeding behaviors cease. Queens typically return to proestrus within 1–3 weeks, although this period is variable and may range from 3 days to 7 weeks. If ovulation occurs during estrus, diestrus follows. Corpora lutea form within 24–48 hr of ovulation and begin secreting progesterone. They remain functional for 30–50 days in the nonpregnant queen, at which time regression occurs. An interestrous interval follows such that diestral queens cease breeding behavior for 33–100 days before proestrus/estrus resumes. Because breeding displays cease in diestrus, this phase is behaviorally indistinguishable from anestrus or interestrus. Anestrus is the period of sexual rest that occurs between October and January in most free-roaming queens. Anestrus queens are sexually noninviting and nonreceptive. They may hiss or strike out at toms that make sexual advances.

The domestic cat is an induced ovulator. Until recently, queens were believed to require copulation or mechanical stimulation of the vagina and cervix for release of luteinizing hormone (LH) and induction of ovulation. Ovulation induced by noncopulatory stimulation also occurs in the cat and is much more common than previously believed. Numerous studies have demonstrated progesterone concentrations consistent with ovulation in nonbred queens (Lawler *et al.,* 1993; Potter *et al.,* 1991; B. Griffin, unpublished observations, 1999). Luteal-phase diseases, including feline inflammatory uterine disease and pyometra, occur in individually housed or nonbred queens. Noncopulatory stimulation capable of inducing ovulation may include the stroke of a hand down the back, other physical stimulation, and visual, auditory, or olfactory cues from a nearby tomcat. Vaginal cytology may be used to assess the stage of estrous in queens, but any method used to obtain a smear may result in sufficient vaginal stimulation to induce ovulation.

Pseudopregnancy occurs when a queen ovulates but does not become pregnant. Clinical signs of pseudopregnancy are rare in the cat but, when present, may include lactation, nesting, and tending kittens. If present, pseudocyesis is usually mild and short-lived and does not require therapy.

Courtship usually occurs at night. Receptive queens sit at a distance from competing males and crouch, roll, and tread in place. The male may approach the female and rub his chin and face against hers in courtship. When the male imitates the female's "heat cry," this is a signal that he is ready to mate. This courtship lasts 10 sec – 5 min and the duration decreases with repeated breedings. Mating is accomplished as the tom grasps the female by the neck with his teeth, grips her forequarters with his front legs, and straddles her with his hindlimbs (Fig. 4). Intromission and ejaculation occur in a few seconds. After the tom releases his grip, the female displays postcoital "after-reaction," which lasts up to several minutes and is characterized by a scream, vigorous rolling and rubbing on the floor, and licking of the vulva. During this time she is unreceptive to the male. Additional mating resumes in 20–30 minutes. Several matings (10–30) occur during the next 24 hr and continue over several days, with the interval between matings becoming increasingly longer.

Tomcats reach puberty between 8 and 13 months of age. They are sexually active year-round, are polygamous, and rarely form long-term bonds with queens. Most tomcats experience peak reproductive function between 2 and 8 years of age. Docile, tractable, easy-to-handle tomcats are ideally suited for breeding, given that studies relate these behavioral traits in kittens, at least in part, to paternity (Reisner *et al.,* 1994 and Turner *et al.,* 1986). Blood type A toms should not be bred to type B queens, to prevent neonatal isoerythrolysis (Casal *et al.,* 1996). Blood type B is rare in domestic shorthairs, but common in certain purebreds.

B. Pregnancy and Parturition

The queen's gestation period is 65–66 days on average with a range of 60–70 days. Large litters typically have a longer gestation period than smaller ones. Serum progesterone concentrations do not significantly differ in pregnant and pseudopregnant cats and therefore are not useful for pregnancy diagnosis. Relaxin is the only pregnancy-specific hormone in cats. Plasma relaxin assays (Witness® Relaxin, Synbiotics Corp., San Diego, CA) may be used to diagnose pregnancy in dogs after days 22–24 of pregnancy and are expected to become available for use in cats. Relaxin is secreted by the placenta. Concentrations increase from days 20–30 post-mating and remain elevated throughout pregnancy. This hormone helps maintain pregnancy and results in relaxation of the connective tissue of the pelvis (Verstegen, 1998). Abdominal palpation is the most common method for diagnosing pregnancy in the queen. Fetuses may be palpated first at 17 days (2.5 weeks) as discrete, firm, spherical nodules (2–2.5 cm in diameter). By day 25, fetuses are no longer discretely palpable. Instead, generalized uteromegaly is evident and remains palpable through parturition. Beyond the 45th day of gestation, fetal heads can be palpated. With experience, palpation is a very reliable method of pregnancy detection and serves as the most economical and practical method in a laboratory setting. Behavioral changes may aid in pregnancy diagnosis, but they typically remain subtle during the first 2 trimesters, when some queens become increasingly docile. By the third trimester, behavioral changes are usually obvious and

include excessive grooming of the mammary glands and perineum and nesting behavior. Occasionally, queens become irritable or defensive during their last week of pregnancy. Physical changes become apparent beginning at 2.5–3 weeks of pregnancy. The queen's nipples become pinker, larger, and more erect. Abdominal distension becomes evident by the fourth week and obvious by the sixth week. Imaging methods used for pregnancy diagnosis include radiography and ultrasound. Calcification of the fetal skeletons may occur as early as day 38 of gestation but is not a reliable finding until day 43; therefore, to ensure diagnostic study, radiography should be performed after day 43 of gestation. Uteromegaly may be seen before this but cannot be distinguished from pyometra or other inflammatory uterine disease. Abdominal radiographs are most useful for evaluating litter size prepartum. Ultrasound is a quick, easy, accurate, safe, and reliable method of pregnancy detection in the cat. Ultrasonographic evidence of pregnancy may be seen as early as 11–14 days, and fetal heartbeats can be recognized at 3.5–4 weeks (Mattoon and Nyland, 1995).

Pregnant cats should be allowed moderate exercise and fed a high-quality feline diet designed for growth or lactation (see Section V,B). Caloric intake increases by approximately one-third by mid-gestation. Stress should be avoided in the pregnant queen, and a quiet, warm, dark nesting area should be provided during the last trimester. Parturition usually occurs at night. Behavioral and physical changes accompany impending parturition (Beaver, 1992). One week prior to parturition, queens seek out dark, dry areas suitable for a nest. An increase in self-grooming and irritability may be noted. Two to 3 days prior to parturition, mammary glands enlarge, and milk may be expressed. Twelve to 24 hr prior to parturition, the queen often exhibits nesting behavior characterized by restlessness, digging at the floor, vocalization, posturing to defecate, and failure to eat. Most queens prefer seclusion at parturition. A decrease in body temperature usually precedes delivery by 12 hr, however, this is not a reliable indicator of labor in the queen. Most litters are delivered within 2 hr, with 15 to 30 min intervals between kittens, but intervals may range from seconds to hours. Occasionally, a delay of 12–48 hr may be noted between kittens. This is usually secondary to disturbances, which may result in delayed parturition and/or moving of the kittens by the queen. Alternatively, the queen may elect to rest during parturition. This should not be confused with dystocia, which is rare in the cat.

C. Infertility

Reproductive failure in domestic cats is uncommon. When present, it is most commonly associated with disease and/or environmental stress. If reproductive failure occurs, affected cats should receive thorough physical examinations, including careful inspection of the external genitalia. Infectious diseases such as feline leukemia virus should be ruled out by performing the appropriate serological testing. Husbandry practices should be critically assessed. Are proper housing, nutrition, and exercise being provided? Are environmental or social stressors evident? For example, has there been a recent environment change, such as pairing a dominant queen with an inexperienced tom? Low-social-order queens may exhibit silent heat (Shille, 1979; Griffin, unpublished observations, 1999). Some queens show aversion to certain toms and preferences for others (Voith, 1980). Early embryonic death and fetal resorption may occur secondary to inherited or infectious diseases, including feline viral rhinotracheitis, feline leukemia virus, feline infectious peritonitis virus, panleukopenia, toxoplasmosis, and a variety of bacterial infections. In addition, fetal defects may contribute to early embryonic death and fetal resorption. Abortion may go unrecognized, because the queen may consume fetal tissues before they are seen. Because female infertility may be due to embryonic death and resorption or unobserved abortion, early pregnancy diagnosis is needed to assess possible contribution of infertility of the tom to reproductive failure. If the male is suspected and physical examination and infectious disease screening are normal/negative, semen evaluation should be performed. Although some tomcats can be trained to ejaculate into an artificial vagina with the use of a teaser queen, most require general anesthesia and electroejaculation for semen collection. Postcoital vaginal cytology is the easiest and most practical method of semen evaluation. Accurate breeding records are essential to evaluate breeding performance. The following information should be recorded for each queen: parents, birth date, date estrus is observed, breeding dates (copulation if observed or exposure to male), identification of breeding tom, results of ultrasound examination (if performed), dates of delivery of each litter, litter size, numbers of male and female kittens, live births, number and cause of stillbirths or neonatal mortality (if known), number of kittens weaned, and date of recurrence of estrus. Periodic review of these records will reveal infertility problems, fecundity, lactation problems, and abnormal viability of kittens *in utero* and postnatally. Queens or toms with a history of recurring poor production should be eliminated from a breeding colony. Inbreeding is a common cause of reduced fecundity, birth defects, and infertility. Breeding records should indicate clearly whether inbreeding is likely to be the cause of reproductive failure, and outbreeding to unrelated cats from minimal-disease stock may solve this problem.

Methods for assisted reproduction in the cat are not as advanced as for mice, cattle, and dogs. Semen can be collected under anesthesia with custom-designed electroejaculators. Cat semen is very small in volume (0.1 ml) and concentrated. Once collected, semen can be diluted in preservative and frozen. Defrosted semen has been used successfully to fertilize ova *in vivo*. Preservation of semen from special stocks, such as important inherited-disease models, can be valuable to ensure against loss due to disease and to reduce the cost of maintenance over long periods (Swanson *et al.*, 1998).

D. Neonatal Care and Weaning

The queen and her new family require warmth, peace, and solitude. Whenever possible, the same personnel should care for queens to prevent stress associated with unfamiliar handlers. This is especially important in the case of new and inexperienced mothers, which may become nervous and trample, injure, or even cannibalize their kittens. Care should be taken to ensure that all kittens nurse as soon as possible after birth. If necessary, kittens should be placed on a teat to suckle. All kittens should be examined individually shortly after birth. Small, cold, or less vigorous kittens should be identified. Such kittens commonly are rejected by the queen, and their survival will require extra assistance in the first few days of life. Feeding supplemental milk replacer to them in addition to the queen's milk may be necessary (see Table IV). The umbilical area of each kitten should be examined. Some mothers may sever the umbilical cord too vigorously or groom the umbilical stump excessively, creating hernias in their kittens. Occasionally, if the umbilical cord is left too long, it may become wrapped around the limb of a kitten, and if not discovered and removed in time, it will dry and shrink, causing strangulation of the limb, with resulting edema and necrosis.

Physical examination of newborn kittens should include an oral exam for cleft palate, which is one of the most common developmental defects in kittens. Affected kittens have difficulty nursing and are predisposed to aspiration pneumonia. Kittens should also be examined for atresia ani, a less common anomaly in which the anus is absent and feces cannot be passed. Surgical correction is possible but usually not practical, necessitating humane euthanasia of affected kittens.

Because newborn kittens are unable to regulate their body temperature, they require a warm environment during the first 3 weeks of life. A local (nesting box) environmental temperature of 90°F should be maintained during the first week of life. After this, kittens are able to shiver, and an environmental temperature of 80°F is adequate during the next 2 weeks. Normally, the queen can provide warmth to the kittens if an insulated nesting box is provided and the room temperature is 75°–80°F. If the room temperature is too low, an external source of heat, such as a recirculating hot-water blanket under the nest box, may be necessary.

At 3–4 weeks of age, kittens are old enough to start eating solid food on their own. Canned food that is softened with additional water should be used to start kittens and offered for 1–2 weeks. The addition of commercially available kitten milk replacer or powdered whole milk to the gruel may stimulate the kittens' interest and appetite. The food should be placed in a shallow pan. Some kittens will eat readily, while others will walk through the food and introduce themselves to the food as they groom. A few kittens will require prompting by opening their mouths and inserting a small bit of food. This simple assistance proves essential for some kittens to begin eating on their own.

Healthy kittens that have reached 550–600 gm body weight may be weaned at 6 weeks of age (Lawler, 1997); however, weaning should not be rushed. The stress of weaning is less if kittens are already consuming adequate quantities of solid food. Kittens should be weaned fully and removed from their mothers by 8–10 weeks of age. After this time, they should be fed a high-quality food formulated for growth. Ideally, kittens should be fed free-choice; however, if meal feeding is necessary, a minimum of 3 or 4 meals per day must be fed. Kittens grow rapidly, attaining 75% of their adult body weight by 6 months of age. By 10–12 months of age, they are full-grown and can be changed to a diet formulated for adult maintenance.

Although most queens are excellent mothers, certain circumstances arise occasionally in breeding colonies that necessitate care of orphan kittens. A queen may die following parturition, reject her kittens, become too ill to care for them, fail to produce sufficient milk, or develop postparturient hypocalcemia or mastitis. Fortunately, most queens will readily foster kittens of another queen. An experienced queen whose own kittens are less than 1 week old or are nearly weaned is the ideal foster mother (Beaver, 1992). Housing together two pregnant queens due to deliver at approximately the same time facilitates shared care of kittens.

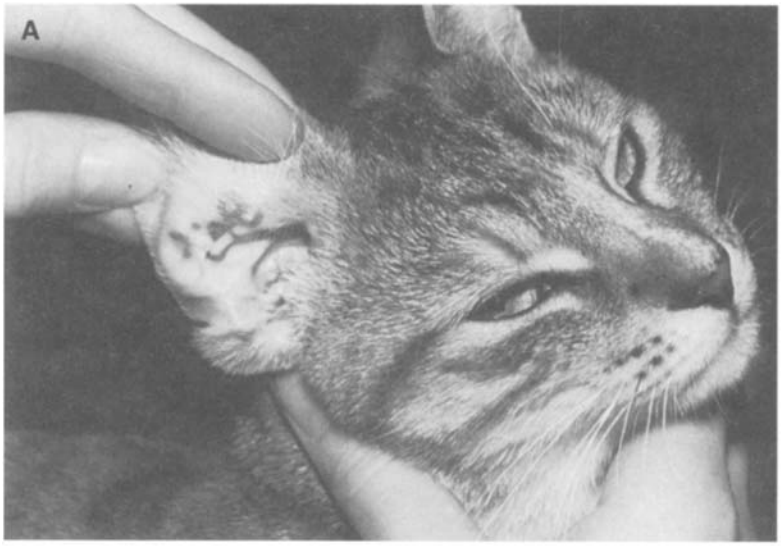
Newborn kittens rely on passive transfer of maternal antibodies for protection against infection. In kittens, passive immunity results primarily from translactational immunoglobulin transfer rather than transfer *in utero*. Intestinal absorption of immunoglobulins ceases after the first 16 hr of life, so newborns must begin nursing within 12 hr of birth in order to receive protective quantities of immunoglobulins (Casal *et al.*, 1996). Kittens not receiving colostrum within 12 hr of birth should be isolated and vaccinated (using a killed product) at 4 weeks of age. Alternatively, injection of newborns with 15 ml serum from a Felv/FIV negative, well-vaccinated adult cat SQ or IP over 24 hours provides adequate passive immunity (Levy, 2000).

If a foster mother is unavailable, kittens may be hand-raised.

Table IV

General Guidelines for Hand-Feeding Orphan Kitten

Week of life	Frequency to feed	Volume of warm milk replacer per feeding
First	Every 2 hours	1.5–2 ml
Second	Every 2 hours	3–4 ml
Third	Every 4 hours	8–10 ml
Fourth	Every 4 hours	10–12 ml
Fifth–Sixth	Every 4–6 hours	Decrease volume and frequency of milk replacer feedings as intake of solid food increases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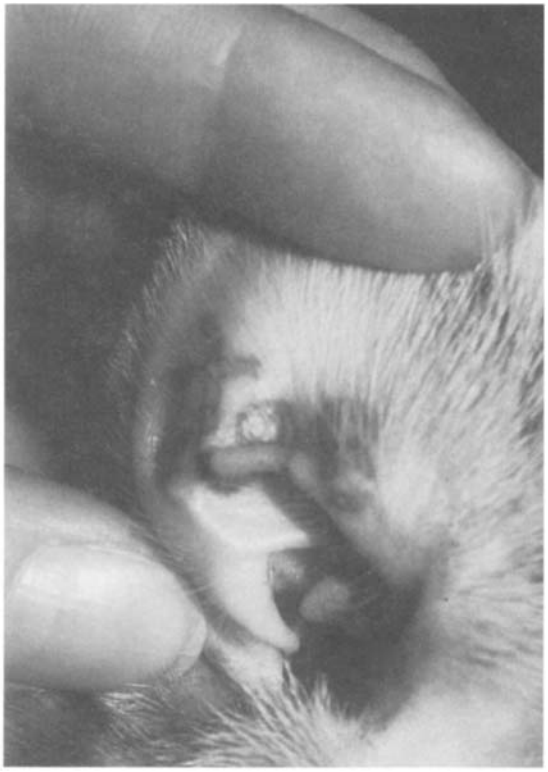


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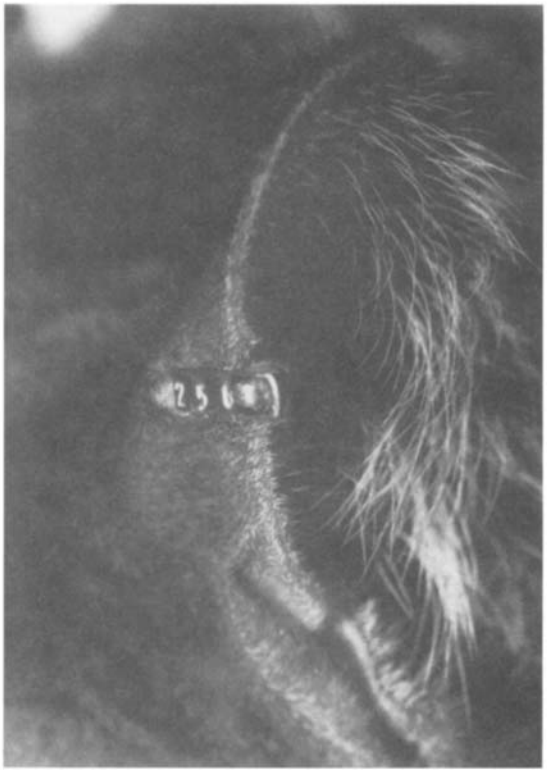

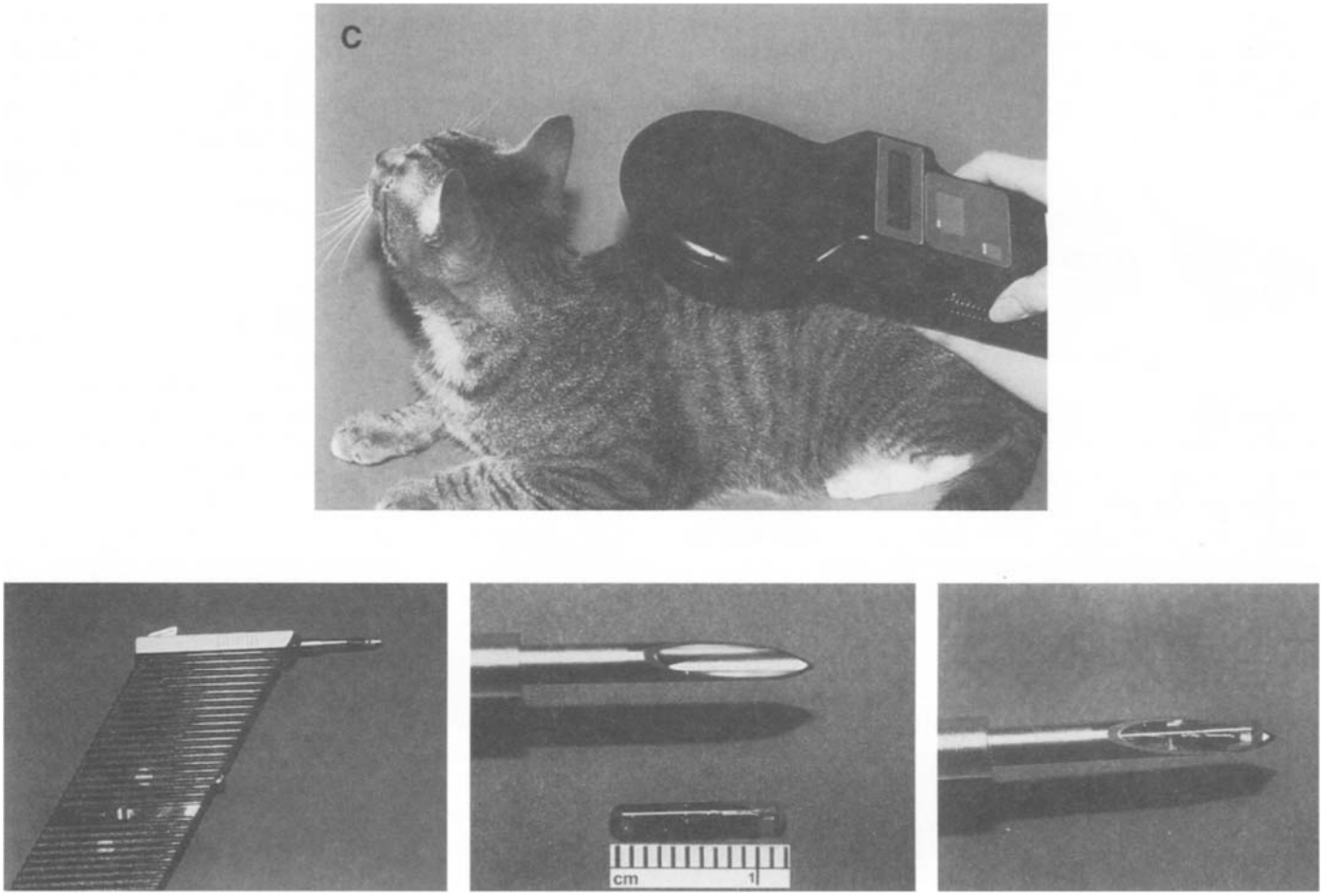

Fig. 5. Commonly used types of identification of individual cats include tattoos, ear tags, and implantable microchips. (a) Permanent tattoo on the inner pinna of the ear of a cat. The medial aspect of the thigh is another common site for tattoo placement; however, growth of hair often makes reading difficult. Heavy sedation is required prior to tattoo placement. (b) Ear tag. Stainless steel bands are manufactured for wing banding of birds and are ideal for identification of young kittens. Skillful placement is necessary to prevent loss or ingrowth by placing the band too far out or into the pinna. (c) Instrument for microchip implantation with close-up views. Microchip is 12 × 2 mm. Cats can quickly and easily be scanned for positive identification.

Hand-raising kittens is time-consuming and sometimes difficult. Kittens should be kept together in a warm nesting box (80°–90°F). Because commercial milk replacement formulas for human infants and puppies do not supply the high levels of fat and protein that kittens require, formulas designed for rearing orphan kittens should be used. Warmed milk replacer (98°–99°F) should be fed via bottle or gastric tube, according to the schedule detailed in Table IV. The kittens and their environment must be kept clean. After each feeding, the anogenital area of each kitten is gently stroked with a soft cotton ball or tissue to stimulate urination and defecation.

Several methods of individual identification are commonly used, including tattooing, placement of ear tags, and microchip implantation (see Fig. 5). Each method has attributes and limitations that recommend their use for specific applications. Tattoos are permanent and may be applied to the inside of the ear or medial aspect of the thigh by using a tattooing machine with multiple needles. Care must be taken to disinfect the needles between individuals. India ink can be used and causes minimal inflammation at the site. Disadvantages of tattooing are that reading is limited by the presence of hair, and the characters can fade over time. Tattooing requires heavy sedation. Ear tags manufactured for wing banding of birds and made of inert stainless steel are especially useful for individual identification of kittens. They must be placed skillfully to provide enough space to accommodate ear growth, while being deep enough to prevent loss. Other complications include inflammation at the puncture site and secondary infection. Ear tags should be considered to be an interim measure until tattooing or microchip placement can be performed. Ear tagging requires sedation except in kittens less than 2 weeks of age. The most secure method is implantation of a microchip subcutaneously in the

space between the shoulder blades. Migration is usually not a complication. Identification does require use of a reader held above the implanted chip site (see Fig. 5). Because of the large diameter of the implantation needle, sedation and/or local anesthesia should be used, and the wound sealed with surgical glue.

V. NUTRITION AND FEEDING

As obligate carnivores, cats are nutritionally and metabolically unique, and their dietary requirements differ considerably from those of most other species. They require diets high in protein and fat but low in carbohydrate. Cats lack the ability to synthesize sufficient quantities of essential nutrients such as taurine, arginine, vitamin A, niacin, and arachidonic acid, which in the wild were present in tissues of their prey. Because their intestinal tract is short relative to that of dogs and other monogastrics, highly digestible diets are preferred (Laflamme, 1994; Buffington, 1991).

A. Commercial Diets

To avoid nutritionally incomplete rations, it is best to select commercially prepared feline diets. The ideal cat food is highly palatable and precisely formulated to provide optimal levels of readily bioavailable nutrients. The nutrients are balanced to the caloric content of the diet, ensuring appropriate intake of each. For best results, cats should be fed a high-quality nutritionally complete diet appropriately formulated for their life stage. When high-quality commercial feline diets are fed, nutritional supplements are unnecessary. Commercially prepared diets should be approved by the Association of American Feed Control Officials (AAFCO), and the method of approval should be considered when selecting a product to feed (Buffington, 1991). AAFCO approval may be based on calculation of the nutritional content of a product's ingredient list, on chemical analysis of its nutritional content, or on feeding trials. In feeding trials, diets are tested by being fed to cats in the life stage for which the product claims to be nutritionally adequate. Unlike nutrient calculation or analysis, feeding trials assess the digestibility, bioavailability, and palatability of a diet, making them the best test of a product's performance. Because labels do not always state the basis of AAFCO approval, one may need to call the manufacturer to ascertain if feeding trials were conducted to validate the nutritional claims of a product.

High-quality commercial feline diets are available in both wet (canned) and dry formulations. Dry foods are relatively inexpensive, convenient, and promote good dental hygiene through the action of chewing. Dry foods are ideal for continuous *ad libitum* feeding because they can be left out overnight without spoiling. Canned foods tend to be highly palatable and energy-dense, although they are more expensive, more labor-intensive to use, and may spoil if left for more than 8–12 hr. Supplementing *ad libitum* dry rations with canned food is ideal in growing kittens and pregnant or nursing queens, who have high energy requirements that are more easily satisfied by a calorically dense canned product.

B. Energy Requirements

Age, life stage, activity level, reproductive status, and environment all affect energy requirements. The energy needs of adult cats at maintenance are 60–80 kcal/kg body weight per day (Laflamme, 1994). Inactive and obese cats require 40–50 kcal/kg body weight per day. Individual cats may vary considerably (up to 20%) in the amount of food necessary to maintain their optimal body weight (Buffington, 1991). Properly fed adult cats should be well muscled but not overweight and should appear well proportioned. The ribs should be readily palpable beneath a thin layer of fat. Viewing the cat from the side, the waist should be moderately tucked up behind the last rib, and the inguinal fat pad should be modest. Cats may be fed *ad libitum* unless portion control becomes necessary to avoid excessive weight gain and obesity. Whereas most sexually intact cats tend to self-regulate their intake, neutered cats tend to eat all food available to them (Flynn et al., 1996). In addition, neutered cats may have lower metabolic rates and require less food than sexually intact cats. If adult cats tend to overeat, portioned feedings twice a day are recommended.

The energy requirements of growing and pregnant animals are greater than those of other adults. Breeding queens should be fed a high-quality feline diet designed for reproduction or growth. Queens gain weight throughout parturition in a linear fashion, with their energy requirements increasing by 25–30% by mid-gestation (Buffington, 1991). After parturition, energy requirements continue to rise to 3–4 times those of maintenance, as queens nurse their kittens (Lawler and Bebiak, 1986). Peak lactation occurs 2–3 weeks postpartum. Maintaining adequate nutrition during this time is extremely important to ensure production of sufficient quantities of high-quality milk, particularly in queens with large litters. Exclusive use of canned foods during the third trimester of pregnancy and during lactation helps ensure adequate energy intake, because these products are more calorically dense than dry foods. After weaning, milk production and mammary congestion can be decreased by fasting queens for 24 hr before returning to maintenance feeding. As always, a continuous supply of fresh, clean drinking water must be available.

Kittens require 250 kcal/kg body weight per day. This gradually decreases over the first year of life until they reach their

adult maintenance requirement. During the first 3–4 weeks of life, kittens receive all nutrients from the queen's milk. Normal birth weight for kittens is 100 ± 10 gm (Lawler and Bebiak, 1986). Healthy kittens should double their weight in the first week of life and continue to gain 5–10% of their body weight daily during the first 3 weeks of life. If there are concerns about adequacy of growth, kittens should be weighed every 2–3 days, and records should be maintained to assess growth (see Section IV,D).

Abrupt diet changes should be avoided. Although some cats readily eat novel diets, others may fast rather than accepting unfamiliar food. Anorexia and rapid weight loss, particularly in obese cats, may result in a life-threatening condition known as hepatic lipidosis, in which severe hepatocellular lipid accumulation leads to impairment of liver function and a variety of other serious metabolic consequences. If changes in diet or feeding schedules are necessary, they should be introduced gradually. Weight reduction, particularly in obese cats, should be accomplished gradually over a period of months to prevent the induction of hepatic lipidosis. If a change is made in a diet that is fed *ad libitum,* the new diet should be mixed in gradually or the old diet should continue to be offered for a limited period of time twice daily until the new diet is accepted. Whenever diet changes are made, food intake should be monitored closely.

C. Feline Lower Urinary Tract Disease

Feline lower urinary tract disease (FLUTD), formerly known as feline urologic syndrome, or FUS, is a complex condition with multiple etiologies. Although the precise etiology or etiologies have yet to be defined, diet may be one contributing factor. Clinical signs associated with FLUTD include hematuria, dysuria, and pollakiuria. Cats may be observed entering the litter box frequently to strain, passing only small amounts of bloody urine each time. In males, urethral obstruction is a common sequela and, without rapid medical intervention, will result in death. The formation of magnesium ammonium phosphate crystals (struvite) is a complicating factor in FLUTD and can be controlled with dietary manipulation. Widely reported research in the 1970s concluded that dietary magnesium was the cause of FLUTD in cats, and low-magnesium diets were recommended to prevent recurrence of the disease (Buffington, 1991). However, recent studies indicate that the most important factor in the development of struvite urolithiasis is urine acidity. Struvite crystals do not form in acid urine (pH ≤ 6.5). In the last decade, cat food manufacturers have included ingredients in their diets to maintain urine acidity, including "digest," a product formed from the hydrolysis of animal tissues and by-products that contains phosphoric acid, which serves as a urinary acidifier. Digest is commonly sprayed on the outside of dry cat foods at 4–10% of the weight of the final finished product. It enhances the palatability of food as much as 2- to 3-fold. Chronic acidification of urine may result in a whole new set of problems for cats, including potassium depletion, renal dysfunction, and formation of calcium oxalate stones.

When clinical signs of FLUTD are present, a complete diagnostic evaluation including urinalysis should be performed to aid in selection of treatment and dietary management. Diet has been shown to be important in the management of FLUTD, especially when struvite urolithiasis is involved. Because FLUTD tends to be a recurrent problem in affected cats, practical recommendations for long-term dietary management usually include feeding diets that acidify the urine and avoiding diets containing excessive dietary magnesium (≤ 20–25 mg magnesium/100 kcal) (Laflamme, 1994). Because precipitation of struvite crystals is intensified by a low volume of urine, use of canned foods is also recommended, because canned foods contain 70–80% water and promote higher urine volume.

VI. INFECTIOUS DISEASE EXCLUSION AND CONTROL

Veterinary graduates are well versed in the breadth of infectious diseases affecting cats, including pathogenesis, diagnosis, and therapy. Additionally, abundant texts and journal references are available on practice management of these diseases. Therefore, this chapter will emphasize infectious disease issues that apply uniquely to colonies of cats and that are critically important to health management of cats used in research.

A. Preventive Medicine

Preventive health care involves recognizing and managing factors that affect disease transmission, including genetics, environmental stress, immunization, disease surveillance, nutrition, and housing design, maintenance, and sanitation (for a description of housing to control infectious diseases, see Section III,D) (Knowles and Gaskell, 1991; Hoskins, 1994; Lawler and Evans, 1997). Selection for disease resistance and docile temperaments that cope better with being housed and handled should be considered. For example, queens repeatedly producing kittens who experience upper respiratory infections (URI) should be removed from breeding stock.

Stress has a profound influence on disease transmission. Stress commonly reactivates latent viral respiratory infections, leading to increased virus shedding and even recurrence of clinical disease (Hawthorne *et al.,* 1995). Simply moving cats from one room to another can precipitate virus shedding. Overcrowding is one of the most potent stressors recognized in cats

(Carlstead *et al.,* 1993; Hoskins, 1994; Lawler, 1997). Overcrowding increases both the number of susceptible animals and the number of asymptomatic carriers in a given group, while increasing the likelihood of disease transmission between group members through both direct contact and exposure to contaminated fomites. Other stressors include irregular schedules of feeding and cleaning, unpredictable daily manipulations, and infrequent or indifferent human contacts (Carlstead *et al.,* 1993). Therefore, effective preventive health care starts with minimization of stress through regular daily activity patterns and environmental enrichment. Group housing of cats ensures social companionship. Installation of shelving allows cats to utilize both horizontal and vertical space, functionally reducing overcrowding by increasing the area available to each cat. Such structures also provide resting and hiding areas and allow cats to escape from aversive stimuli. The provision of toys and cardboard boxes ensures adequate opportunity for scratching and exercise and helps prevent circling, pacing, and other anxiety-related behaviors.

As maternal antibodies wane at 9–14 weeks of age, kittens become increasingly susceptible to a variety of infections, particularly URI and enteric coronavirus, which are commonly enzootic in some cat populations despite optimal preventive medicine and husbandry. To prevent such enzootic infections, early weaning, along with segregation and isolation of litters, has been advocated as a method of minimizing disease transmission (Hawthorne *et al.,* 1995). Although this method may serve to prevent contact of kittens with adults that may be asymptomatic carriers or with acutely infected kittens from other litters, one must consider that early weaning may be inherently stressful (Lawler and Evans, 1997; H. J. Baker, unpublished observations, 1999). Some kittens experience marked separation anxiety, and smaller kittens may benefit from continued nursing. The mother-kitten relationship is extremely important for normal social and emotional development of kittens, particularly singletons.

Exclusion of infectious diseases should be the goal of cat health management because several feline pathogens have the capacity to decimate a cat colony. Procedures to exclude infectious diseases include design of facilities to segregate the colony into subunits that are physically separate, management procedures that prevent or minimize entrance of personnel into more than one room, adequate ventilation and air pressure gradients that prevent recirculation of air or exchange of air between rooms, initiating the colony with disease-free stock, selective use of vaccines, regular health examinations (including serology), daily observations for illness, removal and quarantine of any suspected ill individuals, thorough necropsy examination of seriously ill cats, and, if addition of new cats is required, introduction of only cats of known health history following isolation and quarantine.

B. Pathogen Control

Different strategies should be employed for control of specific infections, depending on their potential threat to the colony, importance as a human health hazard, and availability of effective vaccines. Table II lists basic principles of infectious disease control. For a more comprehensive discusion of control for each of the major pathogens of cats, see Pederson (1995) and Greene (1998).

Although domestic cats are susceptible to a large number of viral diseases, only a few viral diseases are significant for colony-reared cats. Although they are common infections of pet cats, feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV) diseases can be excluded from research colonies by preventive measures described in Section VI,A (see Table V). Feline panleukopenia, caused by a parvovirus, is highly contagious and causes serious clinical disease but fortunately can be controlled easily by vaccination. Kittens should receive modified live-virus vaccines for panleukopenia at 8, 12, and 15 weeks of age. Multivalent vaccines containing feline viral rhinotracheitis, calicivirus, and panleukopenia virus are preferred. Boosters should be administered once every three years. Killed products are recommended in breeding queens. The most serious infectious-disease threats to colony-reared cats are the upper respiratory viruses and feline infectious peritonitis, which are discussed in detail below.

1. Upper Respiratory Infection

Feline viral rhinotracheitis caused by feline herpesvirus (FHV-1) and feline calicivirus (FCV) are the primary etiologic agents in 80% of all upper respiratory infections (URI) in cats (Knowles and Gaskell, 1991; Lawler and Evans, 1997). Other agents, including *Chlamydia, Mycoplasma,* reovirus, and *Bordetella* may be primary, concurrent, or secondary to the viral diseases. *Chlamydia* and *Mycoplasma* commonly cause primary conjunctivitis. *Bordetella* has been implicated recently as a cause of acute bronchitis and pneumonia. Its significance in the pet population is not known, but it can be a serious infection of colonies. A vaccine is available and may be warranted in colonies with a history of Bordetella infection. Clinical signs of URI commonly include depression, inappetence, pyrexia, sneezing and nasal discharge. Conjunctivitis and keratitis are common in FHV-1 infections. Oral and lingual ulceration are common in FCV infections. The severity of clinical signs seen with these diseases is dependent on the age of the cat at infection, the quality and duration of acquired maternal immunity, the duration of exposure, the challenge dose of the virus, and the cat's nutritional plane, stress level, and general health. Once enzootic in a population of cats, upper respiratory viruses manifest mostly as acute disease in young kittens as passive immunity is lost and, at that point, may be difficult to control.

As many as 80% of cats that recover from FHV-1 become car-

Table V

Feline Retroviruses[a]

Disease	Incubation	Transmission	Diagnosis	Clinical signs	Treatment	Prevention
Feline leukemia virus (FeLV)	Weeks to years	Both vertical and horizontal, direct and close contact; mutual grooming; sharing food, water, and litter containers; bite wounds. Virus is continually present in large amounts in saliva, respiratory secretions, and blood in lesser amounts in urine and feces	Screening: antigen test (ELISA). Highly sensitive indicator of viremia. Confirmation with IFA	Wide range of manifestations: aplastic anemia, leukopenia, pancytopenia, lymphadenopathy, immunosuppression, secondary infections, reproductive failure, urinary incontinence, lymphosarcoma, and others	None (supportive care only)	Test and remove. *Note:* Infected cats may not test positive until several weeks postexposure; incoming cats should be tested on entry, isolated for 4 weeks, and retested before joining a colony
Feline immunodeficiency virus (FIV)	Weeks to years	Both vertical and horizontal (primarily bite wounds). Virus is continually present in saliva and blood	Screening: antibody test (ELISA). Confirmation by Western blot	Acquired immunodeficiency syndrome and AIDS-related complex	None (supportive care only)	Test and remove

[a]See Cotter (1990).

riers and intermittently shed virus in oronasal and conjunctival secretions for life (Knowles and Gaskell, 1991; Lawler and Evans, 1997). Under natural conditions, approximately 50% of latently infected cats shed virus following stress. Virus shedding usually begins within 1 week after a stressful episode and continues for approximately 2 weeks. Following FCV infection, cats may shed virus continually for months to years. FHV-1 and FCV persist in the environment for 1–2 days and 8–10 days, respectively. Spread is by direct viral contact through nasal and ocular secretions and via fomites. Transplacental transmission does not occur. The incubation period is 2–6 days, and mortality is low except in young kittens. Clinical signs persist from two days to two weeks in individual cats. In many cats, infections are self-limiting.

Treatment is supportive. Eyes and noses should be kept clean of discharge. Strong-smelling, moist canned foods stimulate the appetite, aid in maintenance of hydration and are gentler on sore throats than dry products. If secondary bacterial infection develops, administration of antibiotics may be necessary. After an enzootic episode, complete elimination of URI is not a realistic goal.

Both parenteral and intranasal vaccine are available for FHV-1 and FCV. Vaccines are safe, but protection may not be complete. Parental vaccines are available in both modified live and inactivated products. Parental modified live vaccines may produce stronger immunity than killed products but should not be given to pregnant queens, to avoid prenatal infection of fetuses. Modified live intranasal vaccines have the advantage of producing rapid local immunity within 2–4 days; however, they frequently induce mild clinical disease. Intranasal vaccination should be strongly considered when URI is a major problem in preweanling or newly weaned kittens. These vaccinations are effective as early as 3–4 weeks of age, and mild vaccine-associated disease is preferable to serious morbidity and mortality from natural disease.

2. Feline Infectious Peritonitis

Feline infectious peritonitis is a potentially important infection of colony cats because it may arise in otherwise healthy cats, cannot be detected serologically, and causes recurring appearance of disease, which is fatal. Two types of coronaviruses infect cats: feline enteric coronavirus (FECV) and feline infectious peritonitis virus (FIPV). They are antigenically and morphologically indistinguishable. FECV is ubiquitous and avirulent. FIPV frequently coexists with FECV and is virulent. Most researchers believe that FIPV is a mutant of FECV. FECV is endemic in nearly all environments where a large number of cats share close quarters. It is associated with subclinical or self-limiting gastrointestinal signs, especially diarrhea. FECV infection commonly approaches 100%, but disease is almost always insignificant and no mortality results. FECV is transmitted via the fecal–oral route. After the virus is ingested, it binds to enterocytes, replicates, and kills the cell. If enough enterocytes are destroyed, a transient diarrhea ensues. Humeral immunity is stimulated as FECV is taken up by mesenteric lymph nodes. Local antibody production blocks further infection of enterocytes.

FIPV differs from FECV in that it is capable of replicating in macrophages. The mutation that allows this to occur confers

potent virulence because the virus is capable of replicating in macrophages that leave the mesenteric lymph nodes and migrate peripherally. FIPV is a systemic intracellular pathogen, but systemic antibodies are not protective. In fact, antibody production may actually enhance disease because complexes formed when antibodies bind with virus result in increased uptake of the virus by macrophages, where further replication occurs. Clinical FIPV disease is most common in young (< 18 months old) and old cats (> 13 years old). It may manifest as an acute vasculitis with pleural and/or peritoneal effusions or as a chronic pyogranulomatous disease. There is no effective treatment once clinical disease is present.

Serological testing does not differentiate FECV from FIPV and therefore is not an effective diagnostic tool. The only definitive diagnosis is postmortem exam. Cats suspected of infection should be humanely euthanized, and a postmortem exam should be performed. Dried virus may survive at room temperature for weeks to months. It is readily destroyed by disinfectants. Litter has been cited as the most important fomite in transmission of this disease. The phenomenon of antibody-dependent enhancement makes vaccination controversial. However, an intranasal vaccine using a temperature-sensitive mutant is available. Early weaning and barrier raising may also be useful management practices to prevent infection of kittens. In addition, proper maintenance and husbandry, including vacuuming of litter particles and cleaning and frequent changing of litter boxes, are important to limit transmission of coronaviruses.

C. Eliminating Parasites

Although cats are susceptible to a wide range of parasites, effective antiparasitic drugs are available, and the high level of sanitation that should be practiced in research colonies makes these easily eliminated. The most common parasites include fleas, ear mites, cestodes, ascarids, hookworms, and coccidia. Fleas cause marked allergic dermatitis in many adults and serve as vectors for transmission of infectious diseases and tapeworms (*Dipylidium caninum*). Several very effective commercial products are available for flea control. Because both cats and kittens are extremely sensitive to toxic effects from insecticides, products should be selected carefully and used only on animals of the age for which they are intended. After eliminating fleas on adult cats, eradication can be achieved because sanitation eliminates opportunities for larval development. Ear mites (*Otodectes cynotis*) are the most common cause of otitis externa in the cat. They live in the external ear canal, feeding on tissue fluids and producing irritation. Their presence results in the formation of a thick, dark brown exudate consisting of cerumen and exfoliated debris. Infested cats shake their heads, scratch their ears, and often excoriate their pinnae. Untreated infestations may result in permanent damage to the ear. Diagnosis is made on close visual inspection of aural exudate where the mites are barely visible with the naked eye or by microscopic examination of exudate in mineral oil at ×10 magnification with a light microscope. If ear mites are diagnosed in a colony, all cats, whether infected or not, should be treated. Although not labeled for this use, ivermectin (200–300 μg/kg SQ q2 weeks × 2 treatments) is safe, practical, inexpensive, and extremely effective.

Endoparasites include ascarids or roundworms (*Toxocara cati* and *Toxascaris leonina*), hookworms (*Ancylostoma* and *Uncinaria*), and coccidia. Transmammary transmission is the most common route of transmission for both roundworms and hookworms, although cats may become infested by ingesting contaminated soil. Larvae ingested by adult cats migrate to body tissues and persist for years. During pregnancy, these larvae are reactivated and travel to the mammary glands, where they are shed into the milk and ingested by nursing neonates. Infested kittens may develop diarrhea as early as 2–3 weeks of age. Hookworms cause blood loss and anemia. Female worms produce eggs that pass in the feces and may persist in the soil for years. Control is readily achieved through proper sanitation and routine deworming of kittens. Pyrantel pamoate (8–10 mg/kg PO q3 weeks × 3 treatments) is highly effective against both roundworms and hookworms and is cost-effective and easy to administer. Adult cats acquire immunity and rarely experience reinfestation. In humans, hookworms and ascarids are associated with cutaneous larval migrans and visceral larval migrans, respectively. Protozoal parasites (coccidia and, less commonly, giardia) may occur in conditions of poor sanitation, particularly in kittens. Parasitization of the small intestine may result in diarrhea. Although uncommon, giardiasis is potentially zoonotic. Eradication consists of treatment of all cats with giardiacidal drugs (metronidazole at 50 mg/kg PO daily for 5 days or fenbendazole at 50 mg/kg PO daily for 5 days) and proper sanitation.

D. Personnel Health Risks

A selected list of infections of cats with zoonotic potential are listed in Table VI. More complete lists are available in the literature (Lappin, 1993; Evans, 1997). Although no potential human health risk should be underestimated, in fact there are only a few of these infections that should be of any concern for a minimal-disease, closed cat colony. Infections of concern include cat scratch disease, dermatophytosis, and toxoplasmosis. There is little that can be done about cat scratch disease except to avoid cat scratch and bite injuries and to be aware of the potential for this infection in a wound that does not respond to the usual treatment. Dermatophytosis can be diagnosed by culture of the organism. It can be a difficult disease to treat in large groups of cats, and if treatment is attempted, the risk of human exposure must be considered (Moriello, 1995; Moriello and DeBoer, 1995). Toxoplasmosis is an obligate intracellular

Table VI

Selected Feline Zoonotic Diseases

Disease	Etiologic agent	Transmission	Diagnosis	Clinical signs		Control and prevention
				Cats	Humans	
Cat scratch disease (CSD)	*Bartonella henselae* (intracellular bacterial parasite)	From cat to cat through close contact and possibly fleas From cat to human through scratches and bites (poorly understood)	Serology	Subclinical	Typical CSD: erythematous papular eruptions at site of inoculation within 2 days–2 weeks of cat scratch, followed by regional lymphadenopathy in 1–7 weeks; systemic signs: fever, malaise, anorexia in approximately 30% of cases Atypical CSD: (rare) CNS signs, focal or multifocal	Flea control Avoid scratch and bite wounds Wounds should be cleaned and disinfected immediately
Dermatophytosis (ringworm)	*Microsporum canis, Trichophyton mentagrophytes*	Direct contact with infected cats or humans, with carriers, or with fomites (spores live 18+ months)	Wood's lamp, fungal culture	Focal or multifocal dermatitis characterized by any combination of hair loss, scaling, crusting, erythema, and miliary dermatitis with variable pruritis	Focal or multifocal dermatitis of variable appearance, classic appearance: circular erythematous lesions	Environmental sanitation (thorough vacuuming followed by bleach at 1:10). For cats, topical therapy with lime sulfur dips twice a week plus systemic therapy with griseofulvin (50 mg/kg PO q day) or itraconazole (10 mg/kg POq day). All exposed cats should be treated, whether infected or not
Pasteurellosis	*Pasteurella multocida* (gram-negative bacillus)	Normal flora of nasal and oral cavities of cats Cat to cat or cat to human, via bite wounds or scratches	All cat bite wounds should be considered contaminated with *Pasteurella*	Cellulitis and abscessation at site of wound(s)	May become rapidly systemic and life-threatening in humans	Prevent bites and scratches through proper handling of cats. Immediate disinfection of all wounds. Antibiotic therapy for all puncture wounds. Amoxicillin (10 mg/lb PO BID) is the drug of choice in cats. Humans with cat bite wounds should consult a physician!
Toxoplasmosis	*Toxoplasma gondii* (obligate intracellular coccidian parasite)	Ingestion of oocysts in raw or poorly cooked meats; environmental contamination from sporulated oocysts in feces is possible in human beings	Serology	Usually subclinical; severe multifocal systemic disease may occur in immunocompromised individuals	Usually subclinical; may have transient flu-like symptoms. Abortion, stillbirths, or birth defects may occur in pregnant women	Avoid undercooked and raw meat; change litter boxes daily to prevent sporulation, which occurs in 1–5 days

protozoan parasite that can be transmitted to cats and humans by ingestion of infected feces/soil or undercooked meat. Diagnosis is difficult, but the simple expedient of changing litter daily, using gloves when handling litter and litter pans, and washing hands will essentially eliminate risk. Rabies vaccination of cats should be considered because of legal obligations and interstate shipping regulations; otherwise there is little or no risk to cats maintained in a closed colony derived from disease-free stock.

Cat salivary and urine proteins are potent allergens, and many people experience severe allergic reactions when exposed to cats. Because of high-density housing in the laboratory, special precautions must be taken to exclude allergic personnel from working with cats and to reduce the potential for induction of allergy. Personnel with known allergy to cats should not work with them unless they take special precautions such as using face masks and gloves.

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